DRIVING AWAY FOOD INSECURITY:
MAPPING MUNCIE, INDIANA MOBILE MARKET LOCATIONS THROUGH GIS AND COMMUNITY ENGAGEMENT

A CREATIVE PROJECT

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ABSTRACT

CREATIVE PROJECT: DRIVING AWAY FOOD INSECURITY:
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The recent trends of suburban migration and the expansion of agro-industry around the United States have contributed to the abandonment of retail food outlets in low-income and low-access urban communities across the country. USDA definitions of food deserts are based on distance from food stores to residential tracts. This definition frames the issue as primarily one of food supply, although empirical evidence suggests that other factors may outweigh distance-based relationships. As a response to these challenges, entrepreneurial efforts in many communities have attempted localized solutions to improving the accessibility and affordability of fresh food, such as community supported agriculture and farmers' markets. In recent years, many mobile operations have attempted to fill this local grocery niche, but in most cases found only moderate and inconsistent success. This research attempts to uncover these challenges to success and provide a framework that will assist in mobile market location planning and implementation. Toward this, I recruited 15 Muncie, Indiana residents to participate in a five-day study to track their daily mobility and maintain a journal of food provisioning activities. A paper survey was used to identify purchasing considerations while journal entries and Participatory GIS group mapping sessions informed real-world behavior. Data was analyzed

using GIS multi-criteria evaluation tools to identify mobile market locations around Muncie, Indiana intended to yield both high community impact and high financial return. I explore how urban food access and purchasing habits may be dependent upon other community features such as neighborhood amenities and access to reliable transportation and advance ideas about the potential use of this framework in other contexts.

DEDICATION

This research is dedicated to the people of Muncie, Indiana; a creative and vibrant community with passionate citizens that nurtured my wife and I in the early years of our marriage. It is my hope that the results of my work can be used to alleviate the food insecurity so prevalent in this region.

ACKNOWLEDGEMENTS

I would like to extend the deepest thanks to my advisor, Dr. Joshua Gruver, who has proven to be an ever-present and invaluable mentor and friend. I will miss our evening philosophizing over beers followed by all-too-early morning meetings over coffee.

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I am also grateful to Dr. Adam Berland who introduced me to GIS mapping processes and was my sounding-board and troubleshooter for the seemingly unending errors I encountered while trying to create and integrate the necessary maps.

Thank you to Michael and Sara O'Donnell who helped me scratch my itch for manual labor through working on their organic farm, and provided me a more complete understanding of the perspective and issues facing local, small-scale farmers.

Most of all, I would like to thank my wife, Mary Tuttle Imboden. You motivate me each day to transform myself into a better person and husband than I was the day before. Without your encouragement, advice, and support, I would have never found myself in graduate school, much less completing my own research and writing. Thank you for sharing this journey with me, all while keeping busy with a PhD of your own!

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INTRODUCTION

The recent trends of suburban migration and the expansion of agro-industry around the United States have contributed to the abandonment of retail food outlets in low-income and low-access (LILA) urban communities around the United States. Local groceries and corner stores that once thrived in neighborhood communities providing local, fresh, and healthy produce have crumbled beneath the pressure of supermarket stores. A majority of food outlets that remain in urban areas are convenience and variety stores that sell limited varieties of fruits and vegetables of marginal quality at inflated prices. The already strained financial condition of these LILA populations, in addition to inadequate public transportation and unreliable automobile access, create serious issues for food access.

Muncie, Indiana lies within a USDA defined food desert. According to the Indiana State Report, 17.7% of homes in Delaware County, IN are food insecure. This is 2.4% above the Indiana average of 15.3%, and 5.0% above the United States average of 12.7%. 54% of families live below the threshold for SNAP coupons with an annual income less than $31,525 (RWJF and UWPHI, 2018). Ironically, this community that has shown an inability to access affordable, healthy food is surrounded by productive farmland.

Value based alternative food networks that place renewed emphasis on where and how products are grown and distributed, have emerged in similarly disadvantaged communities nationwide. This attempt to relink food to place operates within a sustainable and small-scale conceptual framework that is in direct conflict with the current globalized and technocratic food system (Feagan, 2004) and as such, is not without its challenges. Available land has increasingly been converted into commodity crop production, forcing a community's produce supply to be sourced from farther and farther away as the remaining growers lack the yield potential and the

aggregation and distribution infrastructure to distribute produce locally. As a response to these challenges, entrepreneurial communities have attempted localized solutions to improving the accessibility and affordability of fresh food such as community supported agriculture, farmer's markets, and mobile markets.

This research emphasizes the importance of mobile food markets in Delaware county as well as other areas of the United States that have high rates of food insecurity. Mobile markets have the potential to increase resident's access to healthy foods such as fruits and vegetables in regions of the county considered to be food deserts. This helps to relieve food insecurity by reducing the average distance to healthy foods, minimizing travel costs, and increasing the likelihood that low-income residents will maintain a healthy diet. Being that diet is associated with non-communicable diseases including cardiovascular disease, cancer, diabetes, obesity, etc., these markets may help to prevent and control disease, potentially reducing healthcare costs.

Problem and Objectives

Mobile markets are becoming increasingly popular and often operate with the explicit goal of confronting food access inequalities by selling products to underserved areas for minimal profit. Product sales alone often do not cover operating expenses and many operations turn to external funding sources to maintain viability (Bartley and Best, 2013; Robinson, 2016). However, mobile markets lack extensive research limiting our knowledge on what customer locations should be prioritized in order to simultaneously maximize both profit and public benefit.

The overarching goal of this research is the creation of a framework that can optimize market location planning procedures appropriate for Muncie, Indiana, but with the ability to be

applied to similar communities around the United States. This research hopes to determine favorable market locations in areas with both high community impact and high financial return by answering the following questions: What are the locations in Muncie, Indiana that a mobile market would have the greatest impact in countering food insecurity; and what are the locations in Muncie, Indiana that a mobile market can maximize produce sales?

The first of these questions can be answered by determining locations of lowest median household income, distance from traditional retail grocery options and poor or indirect public transportation, low percentage of SNAP coupons redeemed to SNAP coupons awarded, and centralized housing complexes with residents of limited vehicle access and hampered personal mobility (due to age, illness, injury, etc.). The second question will be addressed by targeting locations of highest household income, high walkability, and low crime rates.

LITERATURE REVIEW

Investigating food security and acquisition patterns

Decades of governmental policy, centralized food production, and increased efficiencies of scale has encouraged the replacement of local food networks with globalized ones (Hardesty, 2010; Lyson, 2007). Simultaneously, the persistence of racial segregation and inequality has compelled spatial assimilation of minority populations in order to overcome collective challenges of "laissez-faire" discrimination, such as the decay of neighborhood disinvestment and retail abandonment (Bobo et al., 1997; Miller et al., 2015). Brought to wide attention by First Lady, Michelle Obama, and her *Let's Move!* initiative, in combination with growing empirical research about chronic health conditions, mortality, and morbidity risks, 'food deserts' have become a more widely studied concept (Bassano et al., 2002, Hendrickson et al., 2006; Joshipura et al., 2001). While a food desert is traditionally measured by threefold criteria of distance, income and price, and fresh food availability, contemporary scholars (Miller et al., 2015) argue that race, poverty, and nutritional food access are undeniably intertwined in the geography of food security.

Without the ability to directly address racial components of access, contemporary value-driven local food movements have sought to overcome the social and physical factors impeding food access. Multiple studies examine the ways in which farmers' markets, community supported agriculture (CSA), and mobile markets attempt to improve access to healthy food (Alaimo at al., 2008; Dollahite et al., 2005; McCormack et al., 2010; Robinson et al., 2016). Currently operating in approximately fifty communities around the United States, mobile markets are "essentially farm stands on wheels" and have the benefit of flexibility; capable of

bringing produce into a variety of strategically selected areas without the overhead of brick-and-mortar stores (Robinson et al., 2016).

As there is no one-size-fits-all model for mobile markets, market models are as varied as they are numerous. Generally, mobile markets focus on one or both of these goals: to increase access to healthy foods for underserved populations, and to increase market access for local farmers. Service areas often focus on communities in food deserts lacking traditional grocery options or those particularly challenged by mobility and transportation (Sifferlin, 2012; Windmoeller, 2012; Zepeda, et al. 2014). These markets tend to have small customer bases resulting in low product sales usually insufficient for covering operating expenses (Robinson et al., 2016). Previous researchers have shed light on a variety of factors that affect market viability and influence people's food acquisition patterns and motivations (e.g. cultural, financial, spatial, structural, and temporal motivations), but none have considered these five factors together.

Contrary to the definition of food desert – as well as the key benefit of a mobile market – depending primarily on the *spatial* factor (distance), several studies show that proximity to food outlets is of little consequence for food acquisition (LeClair and Aksan, 2014; Shannon, 2015). As an alternative explanation, the *structural* environment may play a larger role in consumer decision-making as some consumers were found to prioritize markets along direct bus routes over more complicated, although shorter, routes to larger supermarkets (Shannon, 2015). It is also reported that *temporal* considerations of operating hours and seasonality affect market use especially for households working during traditional business hours (Kato, 2015). *Financial* factors prove to be perhaps the most complex of all the motivations as there are individuals who report that price is of the utmost importance when considering where to shop, but consumer

actions show that people are willing to travel farther and pay higher prices when considering convenience, selection, and quality (Kato, 2015; LeClair and Aksan, 2014; Shannon, 2015). Other hypothesized motivations for choosing where to shop are *cultural* in nature. Miller argues that desire for racial assimilation will motivate people to remain within a homogenous cultural population when shopping. Other studies have found individuals engaging in alternative food networks located in predominantly white and middle class social spaces were mostly positive, questioning the extent to which cultural constrains impact consumption (Kato, 2015; Miller et al., 2015). Also, individuals are sometimes compelled to select less nutritious food even when educated on the health benefits of fresh produce due to perceptions of safety and grocery employee rapport (Hendrickson et al., 2006; Kato, 2015; Shannon, 2015). The motivations for food purchases are varied and interdependent, and no single consideration trumps all others. Each factor should not be considered without congruent consideration of all factors.

Grassroots data gathering for social geography and urban planning

Traditional GIS has become increasingly criticized for the lack of nuance in the view it provides of real-world social spaces. Measurements that are bounded by often arbitrarily defined lines and point locations can create the illusion of stark contrasts across imaginary boundaries that may better resemble a gradient, in reality. In addition, computer programs are best adapted for displaying quantitative data; temperatures, crime rates, population density, etc. but struggle at visualizing cultural, and experiential knowledge. The emerging field of Participatory GIS (PGIS) assists in bringing community member input to public planning discussions to incorporate local knowledge that is quantitative and visual for GIS decision-making (Elwood, 2006).

PGIS intervenes against entrenched powers on behalf of those traditionally denied a seat at the planning table allowing for people to operationalize their own values with respect to topics directly impacting their lives. This presence of public input is believed to allow government or corporate actions to better reflect the perceived need of their target demographic, and allows benefits to be more equally distributed among the community (Radil, 2015). A 2003 publication from the Department of Housing and Urban Development (HUD) has called for more consistent integration of local data into spatial data infrastructures (Committee on Review of Geographic Information Systems Research and Applications and HUD, 2003; Elwood, 2008). Meanings and interpretations of participating individuals (and groups) are shaped by differences in race, gender, class, and ethnicity that are inextricably linked to their institutional relationships, cultures and past experiences (Elwood, 2006). Community decision making must include the views of the most marginalized if restoration and community action initiatives are to be successful for all citizens.

METHODS

This research utilized both quantitative data available from the United States Census Bureau and other public GIS databases, as well as qualitative data sourced from the community in three phases; surveys, participant journaling, and community participatory data gathering sessions (referred to as focus groups). Each phase of data gathering provided unique information, from which the researcher was able to build a total of fifteen suitability raster maps. Each map reflected areas of increased or decreased favorability for a mobile market location. For instance, areas closer to population dense locations or areas closer to public transportation routes are were considered by the researcher to be more favorable, while more rural or crime-impacted areas were deemed less favorable. These were then combined into five maps, each displaying one of the five motivations for food acquisition behavior that were the focus of this research (e.g. cultural, financial, spatial, structural, and temporal motivations). The fifteen survey participants were asked to rank the importance of each of these motivations against each other on a scale of 1 to 5, with 5 being the most important, providing a numerical value of the importance of each motivation relative to the others. Finally, the five resulting maps were combined again using a weighted formula as determined by the survey. This map combined the mobile market favorability values from all fifteen maps; the most influence being granted to the maps the participants indicated most important.

Recruitment and Participant Data Gathering

Journal and focus group participants were recruited by attending neighborhood association meetings. Additional participants were contacted for participation at the suggestion of Neighborhood Association leaders. These participants were selected based on their

embeddedness in Muncie community agencies as and activities. The inclusion of these 'everyday' citizens is a strategy in overcoming boundaries that reinforce the marginalization of underrepresented sections of a community (Reddy, 2010). Participating neighborhoods were selected through a thorough investigation of ethnic, financial, and proximal differences in order to reach a cross section of all demographics of Muncie, IN. GIS processes revealed priority Muncie neighborhoods that experience the highest density of citizens experiencing racial and financial inequities. Five neighborhood association leaders were also asked to participate because of their knowledge of local environments and intimate understanding of the needs of their own neighbors.

The graduate researcher recruited survey participants by attending the selected Muncie neighborhood association meetings where the purpose for the research as well as the methodology was shared with all attendees. Participation was encouraged through an incentive program where each participant was entered into a random drawing for a gift card of fifty dollars to be mailed at the conclusion of the research. Individuals indicated their interest in participation by submitting their contact information to the graduate researcher. Participants were required to live or work within the city limits of Muncie, Indiana. Out of these interested and eligible participants, the researcher randomly selected 25 individuals to participate and invited participants to two sessions; the first session for survey completion and journal distribution, and the second for journal collection and participatory GIS group mapping sessions. Each session was offered three times on varying days of the week and times of day in order to accommodate the varying schedules of participants. Low participant turnout motivated the researcher to amend the survey to include a mapping portion similar to the activities during the group mapping sessions and distribute them to the neighborhood association members that had previously shown

interest, but were unable to attend scheduled sessions. These amended surveys were distributed with a stamped and addressed envelope to that completed surveys could be returned to the researcher upon their completion. Out of the 25 individuals selected to participate, 15 surveys were completed and returned.

Qualitative: Surveys, Journals, and Participatory GIS Focus Groups

Surveys provided self-reported data on grocery shopping habits (i.e. timing, frequency, method of transportation, types of food purchased) and personal opinions on purchasing motivations (i.e. prioritizing local foods, considerations of cost, etc.). Following the survey, these same participants were asked to maintain a food journal providing details on their mobility and food procurement over a one week period to account for both work day and non-work day behaviors. Information relevant to the researcher was be food procurement practices outside the home including: time of day of food shopping, visits to food pantries, food ordered from restaurants, and food consumed at another residence; means of travel to and from procurement areas; number of and relation to fellow shoppers. Participants were provided with a grocery journal in which to track their purchasing habits in real-time over no less than five days, with the intention of verifying their self-reported behavior with their real world actions. Out of the fifteen journals distributed, a total of five were completed and returned to the researcher.

All five journal participants also participated in a group session discussing mobility and other food behaviors that took place during the study period, realizations that may have occurred regarding the food environment in Muncie, IN. This session also provided participants opportunity to provide feedback to the researcher regarding the perceived need (or not) of a mobile market. Participants then engaged in a Participatory GIS group mapping session, to

allow for the inclusion of local spatial knowledge into the GIS process. These sessions provided participants the opportunity to share knowledge of their physical environment, identify frequent community gathering spaces that may not have been visited during the study period, pinpoint locations where they may feel unsafe shopping, and provide direct feedback on where they would appreciate a mobile market location.

Quantitative: Population Census Data, and City Infrastructure

The USDA publishes a food shed assessment toolkit along with monthly national averages of what it should cost to feed households of various sizes and parentages. Using this toolkit, a food security assessment was completed for Muncie, Indiana that shows how the local food environment compares to the national average. All other appropriate 2015 quantitative census data including racial demographics, income, SNAP awards and redemption rates, and vehicle access at the block group level were acquired through the US Census Bureau and the National Historical Geographic Information System databases. City infrastructure data (roads and peak traffic counts, bus routes, paved sidewalks, schools, churches, community gardens, public parks, apartment complexes, senior and disabled living centers, and mobile home parks) were acquired through the Delaware County GIS offices and Ball State University library GIS database.

In order to account for each of my five mappable factors, I used ArcGIS 10.4 software to first map each of the cultural, financial, spatial, structural, and temporal consideration categories individually before using a weighted linear combination to combine all map layers in a multi-criteria evaluation (MCE) process. The derived weight for the MCE will be determined from qualitative data gathered from fifteen study participants. The MCE process will be necessary as

prior studies have shown conflicting priorities influencing food acquisition within and between research communities, and the community data gathering methods will provide insight into the factors which most influence Muncie citizens.

MAPPING AND ANALYSIS

In order to combine each mapped criteria into a new map that reflected site suitability for a mobile market, every factor to be included was rasterized and assigned a value. Each map of inclusion data was plotted on ArcMap version 10.4 and received a raster based on Euclidean distance from the investigated data with cell sizes of approximately 100 feet. This number was chosen for its relative specificity based on the extent of the study area due to the high number and diversity of mapped criteria I combined. With distance computed for each cell, suitability values were then reassigned to the raster based on the distance from the mapped features. Instead of assigning identical values based on distance, each map received individual considerations.

Structural Criteria

The structural category focused on the built-environment and infrastructure around Muncie that may either facilitate or inhibit individuals from accessing grocery outlets. This category included maps for the Muncie bus system (MITS), community living or population dense environments (apartment complexes, mobile home parks, and senior/assisted living centers), and the network of paved sidewalks. Based on tolerated walking time and distance to grocery stores, cells on the MITS and community living rasters within 0.1 miles of a route or community living center were assigned a score of 90, cells between 0.1 miles and 0.25 miles were assigned a score of 75, cells between 0.25 and 0.5 miles were assigned a score of 50, cells between 0.5 miles to 0.75 miles were assigned a score of 25, and all remaining cells outside 0.75 miles from the nearest route or community living center were assigned a score of 0. Quarter-mile intervals were selected because participatory GIS session responses indicated the median

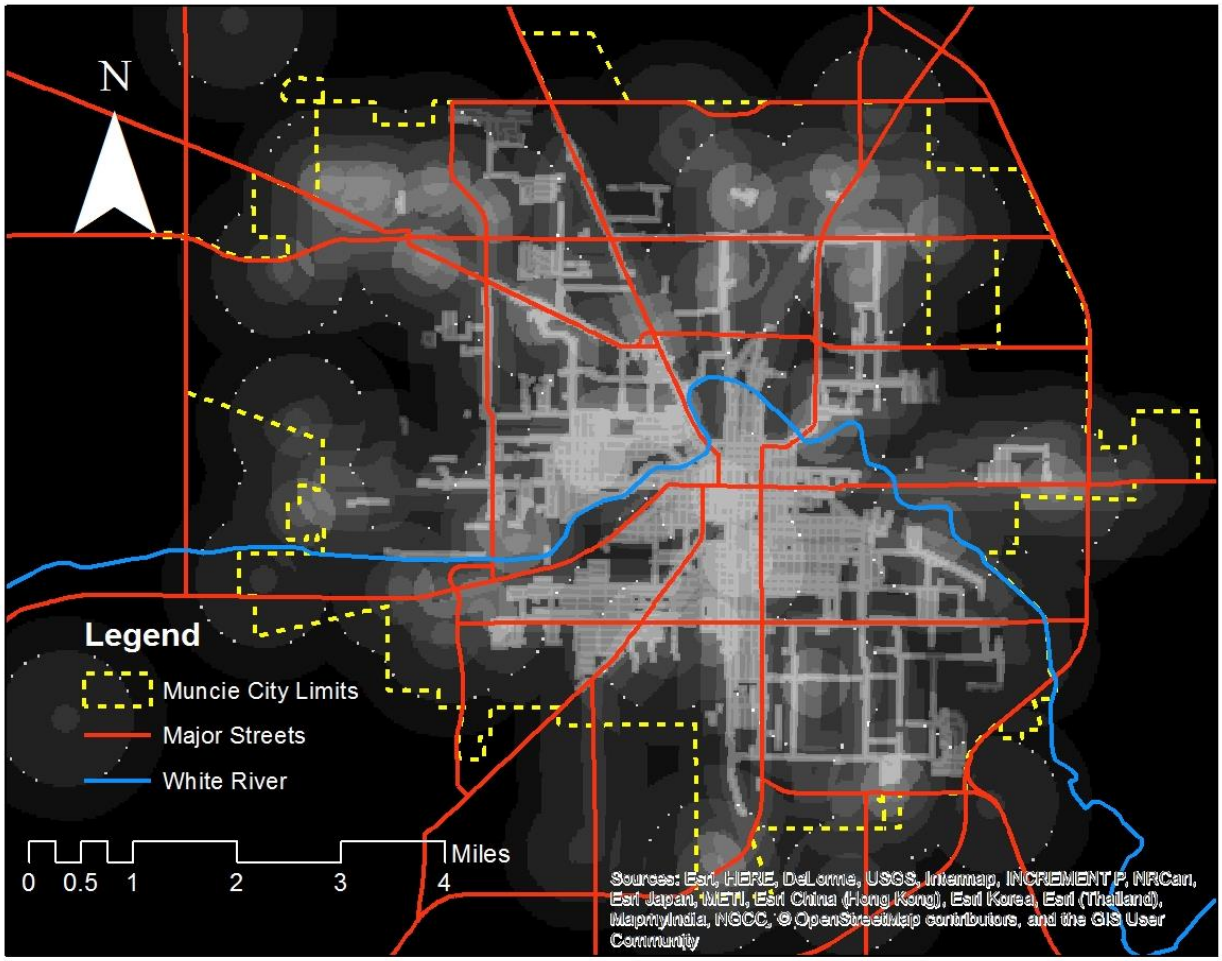


Figure 1*: Combined structural factors*

tolerated walking time to a grocery store would be 10 minutes. At an average walking pace of 3 miles per hour, a person typically traverses a quarter-mile every 5 minutes. The maps of sidewalks was scored differently, with values of 85, 70, and 55, and 0 being reflective of distances of 50, 100, 150, and 150+ feet respectively. This increases the value of the area immediately around the sidewalks rather than having values extend a mile out from the sidewalk in every direction. After preparing all three rasters with their distance-based values, an addition command through the Raster Calculator ArcGIS function created a single raster map reflective of the scores of all structural criteria together (figure 1). The lighter shades on the map indicate areas with higher values that are more conducive to a mobile market based on the mapped

structural criteria. The locations of community living complexes, MITS bus routes, and paved sidewalks can be readily interpreted. The locations where all of these factors overlap appear lighter than the areas where these locations exist in isolation, indicating the increased value of multiple factors combined.

Spatial Criteria

Maps categorized as spatial criteria included locations that accept federal SNAP coupons, the most affordable major grocery outlets based on the USDA market basket analysis, roads that were reported by participants to have the most foot traffic, and locations specifically selected by participants on where to implement the planned Muncie mobile market. Possible values of cells in the SNAP location and major grocery outlet rasters were 100, 75, 50, 25, and 0 which correlated to locations within 0.25, 0.5, 0.75, 1.0 miles, and then beyond 1.0 mile respectively. The values for the distances were determined due to their equal differences (at intervals of twenty-five) and because of the equal distance between the four distance intervals from zero to one mile. Commonly foot trafficked roads were scored differently; each cell within 500 feet of the identified roads was scored at 100, and any cell outside of 500 feet was given 0. This differentiation is wide enough to cover one city block in any direction from the selected roads, but emphasizes the value of those cells due to the specificity of the identified roads from the participatory mapping session. Value tier areas are also smaller in the raster based on the suggested locations for a similar reason that these locations were explicitly identified as desirable locations by community stakeholders, and the resulting map should keep the value of these locations as centralized as possible. Raster values are 100, 90, 80, 70, 60, and 0 at 0.1, 0.2, 0.3, 0.4, 0.5, and greater than 0.5 miles respectively.

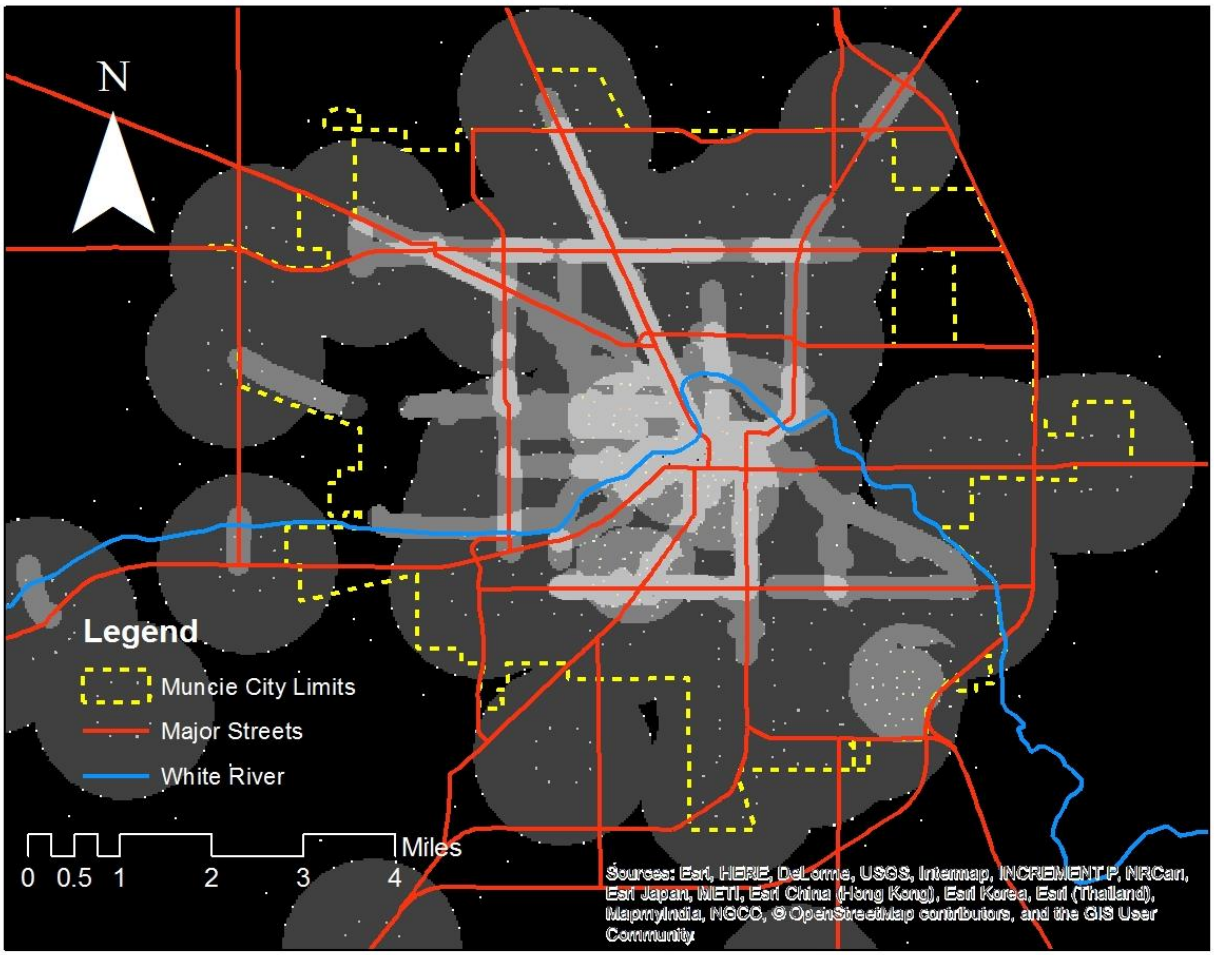


***Figure 2**: Combined spatial factors*

These above four rasters are added together to produce one map reflecting the scores of all spatial criteria combined (figure 2). Similar to figure 1, the areas in figure 2 score higher (and appear lighter) in locations where mapped features from multiple maps overlap. The larger, dark grey circles indicate locations within walking distance of a major grocery chain or grocer that accepts SNAP coupons. When combined with commonly foot-trafficked roads and locations specially chosen by study participants – smaller circles grouped around the center of Muncie – the higher values are represented by increasingly lighter bands of gray and higher levels of market suitability.

Temporal Criteria

The temporal map is meant to capture potential customer availability based on daily movement, because it was reported that people often incorporate their grocery shopping trips into other trips they already planned to complete (i.e. to and from work, weekend or evening activities, etc.) rather than making an out-and-back trip specifically for grocery shopping. Street data available from the Delaware County GIS office included traffic volume counts and peak traffic hours. The top ten percent of heavily trafficked roads were included in this mapped criteria as this data was highly specified: road volume data was not only recorded for each road, but also broken down by stretches of road between every intersection. The values assigned for the traffic map (figure 3) were similar to the sidewalk use in that it was an all-or-nothing

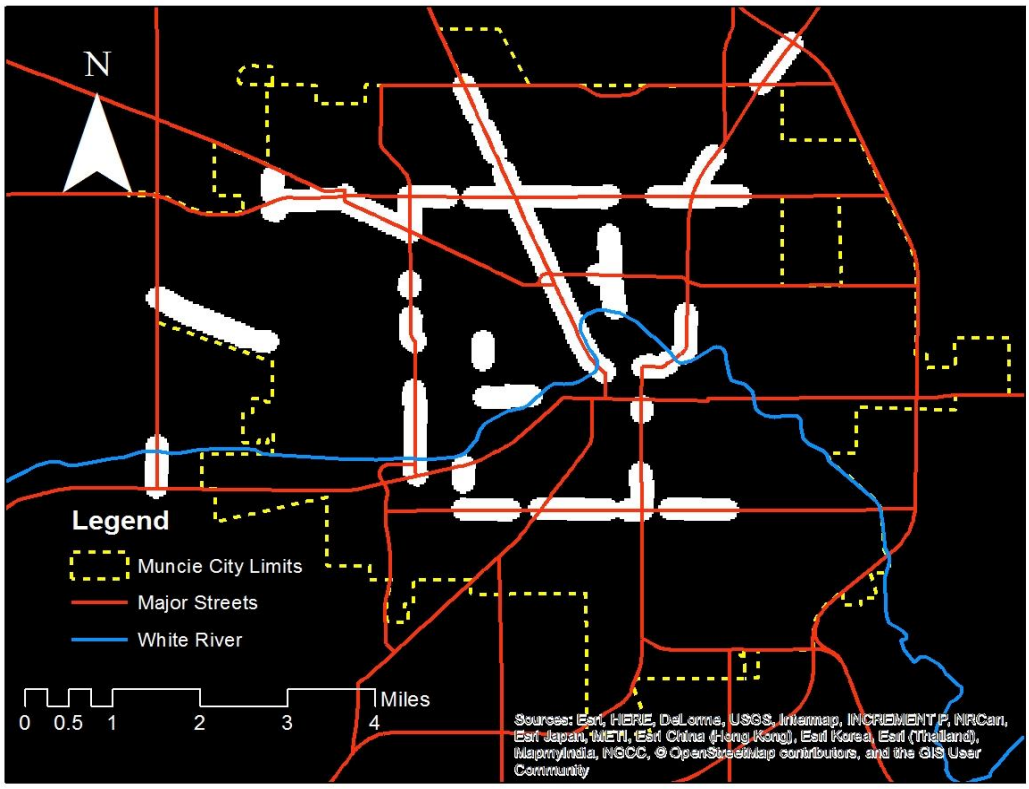


***Figure 3**: Temporal factor of heavily trafficked roads*

designation. The area within 0.1 miles of the identified roads in every direction received a score of 100, while the remaining extrinsic area received a score of 0.

Cultural criteria

Cultural criteria maps are intended to reflect the customer base's lived relationship with their urban environment. This facilitates meeting customers at locations they already frequent, locations they consider central to their daily lives and the lives of their neighbors, and locations they prefer to avoid due to perceived dangers or uncomfortable situations. The map of

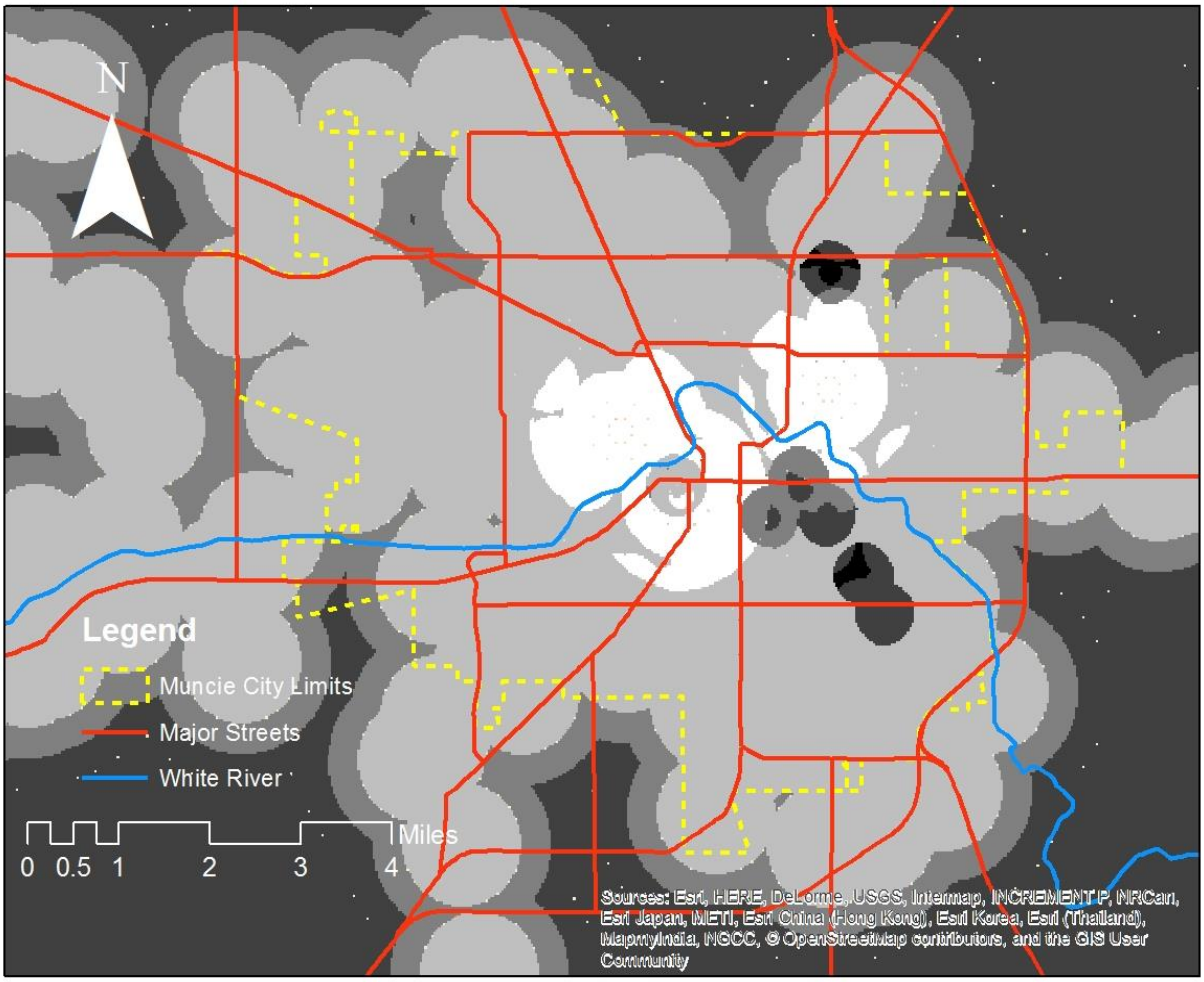


***Figure 4**: Combined cultural factors*

community gathering spaces, which includes central points for churches, schools, community gardens, and city parks, have distance values of 85, 60, 35, and 10 for 0.25, 0.5, 0.75, and 1 mile respectively, while distances greater than 1 mile are valued at zero. Neighborhood centers were proposed by the five participants at participatory mapping focus groups after being asked to identify what they consider to be the center of their neighborhood. The graduate researcher created a map of identified locations for each neighborhood and assigned values of 100, 85, 60, 35, 10, and 0 for 0.1, 0.25, 0.5, 0.75, and 1 mile respectively. Cultural criteria also included a map where survey and group participants stated that they would prefer to avoid, either because of concerns over crime or personal safety, stores that lack culturally appropriate foods, or locations where they feel they have been treated rudely by employees. This map has negative values of -90 and -75 at 0.1 and 0.25 miles, so when these values are added to the other maps using the raster calculator, it actually *lowers* the combined values of the cultural criteria map (figure 4) where they overlap.

Financial Criteria

The financial criteria considered relevant for the purpose of this research included median household income, percent of households utilizing SNAP coupons, and households with low or no vehicle access. These values are based on census data provided at the block group level instead of distance from identified features. Each financial target was assigned tiered values for each quintile; the lowest quintile of each criteria given a value of 20, then increasing by 20 in each consecutive quintile until the highest quintile having a value of 100. These three maps were then combined though addition in the Raster Calculator to produce a single map reflective of all

have combined to yield a higher total score, while medium gray and dark areas indicate lower or no values. The area including the campus of Ball State University is omitted due to inconsistencies in the data provided by the US Census Bureau.

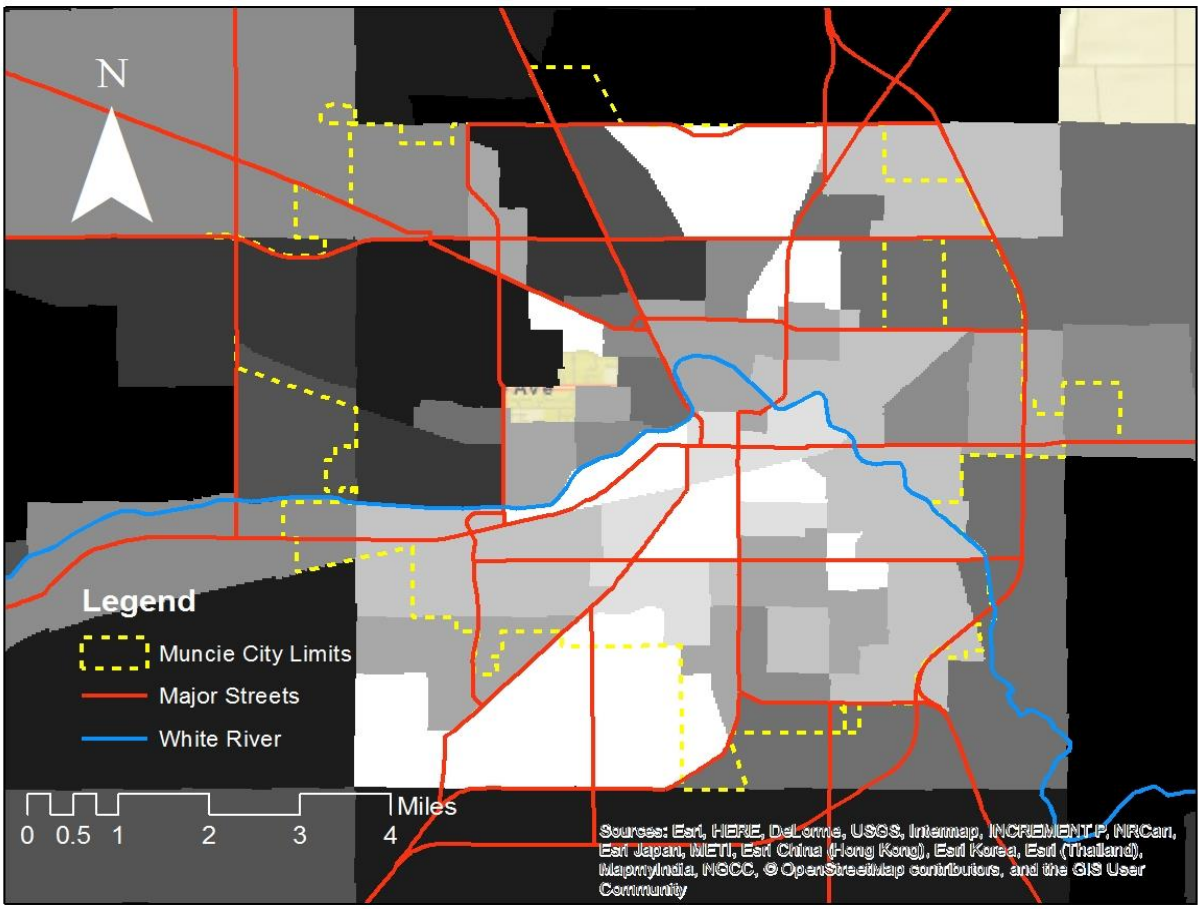


Figure 5*: Combined financial factors*

Combination and Multi-Criteria Evaluation

In order to view a single map that shows mobile market site suitability for all of the mapped criteria, the five maps combination maps need to be joined together. The qualitative data gathered from the grocery habits survey, food diaries, and PGIS focus groups was used to weight the importance of different motivations for procurement locations before being combined through a GIS multi-criteria evaluation process. A simple addition of all maps would weight

each consideration equally, however, as discussed in the literature review and confirmed through the mobile market consumer habits survey, customers do not always place equal value on the five factors when considering where to shop and what to buy. While other researchers have disagreed on which criteria has the greatest impact on purchasing decisions, sourcing the weighting values from the Muncie community customized the resulting map to reflect needs specific to the city. The MCE map of all combined factors reveal locations where a mobile market will have maximum impact in combating accessibility issues and receive greatest financial return.

Participants ranked each of the five factors on a scale of 1 to 5 and each survey response was added together divided by the total points given to all factors to determine the percentage of total points given to each factor. Before adding these five factors together in the raster calculator for the MCE analysis, the values of each raster were multiplied by their weighted percentage: the structural and temporal criteria were each multiplied by 15%, the spatial and cultural criteria by 20%, and the financial criteria was multiplied by 30%. The resulting map (figure 6) provides a view of the most suitable locations for a mobile market in Muncie, Indiana. The highest values on the map reflecting the most desirable market locations based on the 15 different mapped criteria, and weighted by variable importance as identified by study participants. In order to assist in the differentiation of the highest values, the highest scoring areas have been edited to display a dark green, while the next highest areas are a light green, then yellow, orange, and red consecutively.

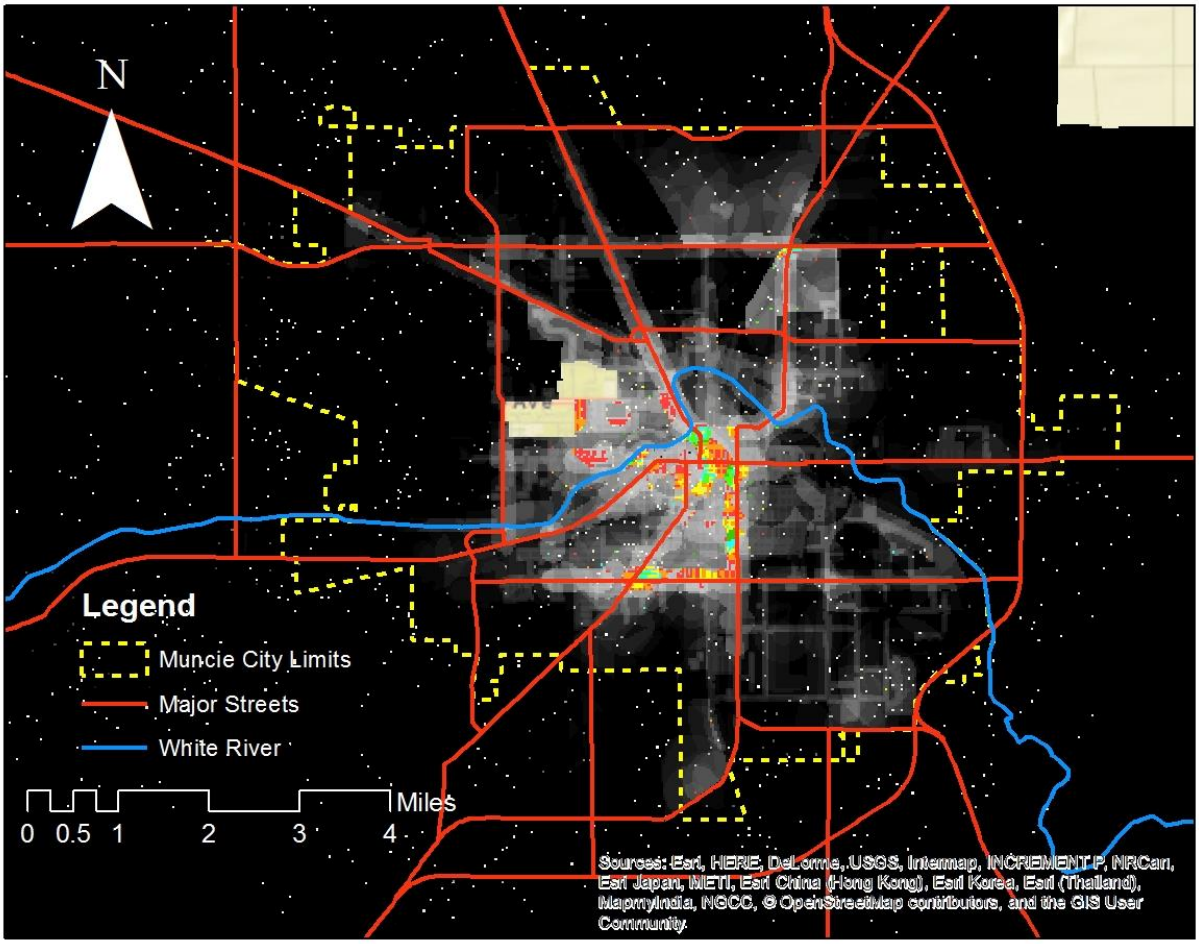


***Figure 6**: Weighted recombination map*

RESULTS AND DISCUSSION

Survey responses showed a distinct dichotomy in responses based on method of transportation – whether they had access to a vehicle or not. An individual reporting that price is the number one consideration when selecting where to shop for their groceries frequently walked or used public transportation to travel to and from the grocery store; these individuals also responded that purchasing local foods is of little or no importance in their shopping habits. This is in contrast to those who exclusively use a personal vehicle to get around in that they consider accessibility due to traffic and or product availability are their highest considerations at grocery locations, and that they place a higher priority on purchasing local foods. It is assumed that those in a household without a vehicle face greater financial hardship than those who are able to drive themselves and prioritize getting the greatest amount of food for the least cost. Those without vehicles also shopped primarily on weekdays, presumably during reliable MITS transportation schedules, while those with a personal vehicle indicated 'no preference' in that they shop when it is most convenient for them.

When comparing these survey responses to the self-reported habits in the grocery journals, the researcher was able to confirm that individuals traveling by personal vehicle shopped at a variety of grocery stores and at a variety of times (although commonly during or after the 5pm rush-hour). Individuals traveling on foot or by public transport were much more likely to shop consistently at a single location presumably along their walking or bus route to/from work. Interestingly, participants who identified cost as the most important factor influencing their shopping decisions did not reliably purchase the lowest cost version of an item. This is because many of these individuals also shopped at a neighborhood grocer or convenience store where product cost is slightly inflated above what large grocery chains and supermarkets

can offer. This suggests that the availability of food for low-income, food desert residents is also subject to convenience and store location; making food (whether it be sourced locally or globally) more easily accessible may outweigh the additional perceived costs of local foods at a supermarket.

The weighted recombination of all maps through the multi-criteria evaluation process can help the Muncie mobile market identify locations where this added convenience can help distribute more food to more individuals. Final market-suitability values ranged from approximately 100 to 230, their representation on the map growing increasingly lighter as the values increases. In order to better differentiate between the similar colors on the map at the highest value, the values from 200 to 240 are represented from greatest to least by dark green, light green, yellow, orange, and red. As supported by the literature, the highest scoring locations in Muncie are clustered around the busier downtown intersections where it was previously known that many of the mapped factors overlap (e.g. sidewalks, heavily foot- and car-trafficked roads, MITS bus routes, population-dense housing complexes, etc.); these locations and their final values are included in table 1. These locations can assist the planned Muncie mobile market in overcoming the initial financial hurdles that trouble new mobile markets. However, even with these features clustered most densely at the center of the city, large variability in final market suitability values are introduced in the multi-criteria evaluation due to the addition of participatory GIS feedback.

Street	Cross Street	Final Raster Value
Jackson	Kilgore (at White River)	230
Madison	7th avenue	225
Madison	Jackson	220
Wysor	High Street and Wheeling	220
(Canan Commons) Walnut	Seymour	218
Martin Luther King, Jr.	McGalliard	217
Hoyt	Memorial	216
Memorial	Walnut	210
Bethel	Marleon	206
Broadway	E Manor Street	200

***Table 1**: The ten highest scoring locations in Muncie, Indiana.*

The value of the multi-criteria evaluation can also be seen extending out from the city center, where although foot and vehicle traffic may decline, other factors such as community gathering centers and smaller grocers accepting SNAP coupons increase the market favorability. These outlying pockets of high combined values are particularly valuable to this research in not only creating financial viability of the market, but also allowing it to reach a larger, more diverse population of citizens.

This research is intended to produce a mobile market site selection framework, ideally replicable in cities around the United States to fill the gap of previously nonexistent operational procedures and best practices, and aid in creating a greater volume of financially stable mobile market programs. This framework optimizes services to areas of the community in need while

also helping the market reach a financially stable state. Other overall benefits of the mobile market include the encouragement of greater consumption of locally-sourced, nutritionally rich foods and additional market outlets for area farmers.

CONCLUSION

The motivations that influence purchasing decisions are many and varied, and each is held to different degrees of importance based on the individual. Future research would benefit by having larger participation, perhaps some of the trends between vehicle access, income, and shopping priorities would be clearer. As I compiled my data and built maps, I would have liked to explore MITS ridership data including an identification of the most frequently traveled routes. This would be beneficial in weighting which routes are being traveled most commonly as opposed to providing an identical accessibility score to all routes, even ones used only sparingly. It would also help to source more mapped data directly from the participants instead of relying on census data. Although deeply informative, the presentation of quantitative information by geographical area (by census block group in the case of this research) can be misleading. Block groups are bounded by ambiguous and arbitrary boundaries, and an individuals' inclusion in one block over another may depend solely on which side of the street they live on.

After completing the MCE analysis, I have found that many locations that are rated highly on one or two criteria maps appear only mildly favorable for a mobile market on the final map. This could cause markets to overlook potentially successful locations in outlying areas. Instead of consulting the map following the analysis to identify the top scoring locations overall, markets should determine a region or neighborhood that they would like to serve, and then look for a high scoring location within that area as a potential starting place. It is the hope of this researcher that this framework can be used to assist future mobile market operations in revitalizing their local food system and reaching financial sustainability. In doing so, increasing market access for local producers as well as providing access for their communities to nutritious foods.

REFERENCES

Alaimo, K., Packnett, E., Miles, R. A., & Kruger, D. J. (2008). Fruit and Vegetable Intake among Urban Community Gardeners. *Journal of Nutrition Education and Behavior*, 40(2), 94-101.

Bartley, B., and A. Best. (2013). Mobile Markets: Applying the food truck model to food access. Alexandria, VA: Arcadia Center for Sustainable Food & Agriculture. http://arcadiafood.org/news/mobile-market-report.

Bazzano, L. A., J. He, L. G. Ogden, C. M. Loria, S. Vupputuri, L. Myers, and P. K. Whelton. (2002). Fruit and vegetable intake and risk of cardiovascular disease in US adults: The first National Health and Examination survey epidemiological follow-up study. *American Journal of Clinical Nutrition*, 76(1): 93-99.

Bobo, L., Kleugel, J., & Smith, R. A. (n.d.). Laissez-faire Racism: the Crystallization of a Kinder, Gentler, Antiblack Ideology (S. A. Tuch & J. K. Martin, Eds.). In Racial Attitudes in the 1990s (pp. 15-41). New York: Oxford University Press.

Dollahite, J. S., Nelson, J. A., Frongillo, E. A., & Griffin, M. R. (2005). Building Community Capacity through Enhanced Collaboration in the Farmers Market Nutrition Program. *Agriculture and Human Values*, 22(3), 339-354.

Elwood, S. (2006). Negotiating Knowledge Production: The Everyday Inclusions, Exclusions, and Contradictions of Participatory GIS Research. *The Professional Geographer*, 58(2), 197-208.

Elwood, S. (2008). Grassroots groups as stakeholders in spatial data infrastructures: challenges and opportunities for local data development and sharing. *International Journal of Geographical Information Science*, 22(1), 71-90.

Feagan, R., Morris, D., & Krug, K. (2004). Niagara region farmers' markets: local food systems and sustainability considerations. *Local Environment*, 9(3), 235-254.

Hardesty, S. D. (2010). Do Government Policies Grow Local Food. *Choices: The Magazine of Food, Farm, and Resource Issues*, 25(1).

Hendrickson, D., Smith, C., & Eikenberry, N. (2006). Fruit and vegetable access in four low-income food deserts communities in Minnesota. *Agriculture and Human Values*, 23(3), 371-383.

Joshipura, K. J. (2001). The Effect of Fruit and Vegetable Intake on Risk for Coronary Heart Disease. *Annals of Internal Medicine*, 134(12), 1106.

Kato, Y., & Mckinney, L. (2014). Bringing food desert residents to an alternative food market: a semi-experimental study of impediments to food access. *Agriculture and Human Values*, 32(2), 215-227.

LeClair, M. S., & Aksan, A. (2014). Redefining the food desert: combining GIS with direct observation to measure food access. *Agriculture and Human Values*, 31(4), 537-547.

Lyson, T. A. (2007). Civic agriculture and the North American food system (C. C. Hinrichs, & T. A. Lyson, Eds.). In remaking the North American Food System: Strategies for Sustainability. Lincoln: University of Nebraska Press.

Mccormack, L. A., Laska, M. N., Larson, N. I., & Story, M. (2010). Review of the Nutritional Implications of Farmers' Markets and Community Gardens: A Call for Evaluation and Research Efforts. *Journal of the American Dietetic Association*, 110(3), 399-408.

Miller, M., Middendorf, G., & Wood, S. D. (2015). Food Availability in the Heartland: Exploring the Effects of Neighborhood Racial and Income Composition. *Rural Sociology*, 80(3), 340-361.

Radil, S. M., & Jiao, J. (2015). Public Participatory GIS and the Geography of Inclusion. *The Professional Geographer*, 68(2), 202-210.

Reddy, S., Estrin, D., & Srivastava, M. (2010). Recruitment Framework for Participatory Sensing Data Collections. *Lecture Notes in Computer Science Pervasive Computing*, 138-155.

RWJF and UWPHI. County Health Rankings. 2018 Indiana State Report. 2018; http://www.countyhealthrankings.org/explore-health-rankings/reports/state-reports/2018/indiana. April 2018.

Robinson, J. A., Weissman, E., Adair, S., Potteiger, M., & Villanueva, J. (2016). An oasis in the desert? The benefits and constraints of mobile markets operating in Syracuse, New York food deserts. *Agriculture and Human Values*, 33(4), 877-893.

Shannon, J. (2015). Beyond the Supermarket Solution: Linking Food Deserts, Neighborhood Context, and Everyday Mobility. *Annals of the American Association of Geographers*, 106(1), 186-202.

Sifferlin, A. (2012). Can "pop-up" grocery stores solve the problem of food deserts? Time, July 24. http://healthand.time.com/2012/07/24/can-pop-up-grocery-stores-solve-the-problem-of-food-deserts.

Windmoeller, M. (2012). Mobile markets. http://www.communitycommons.org/2012/11/mobile-markets-one-food-desert-solution.

Zepeda, L., Reznickova, A., & Lohr, L. (2014). Overcoming challenges to effectiveness of mobile markets in US food deserts. *Appetite*, 79, 58-67.

APPENDICES

APPENDIX I

Survey Instrument

Muncie, Indiana Mobile Market Consumer Habits Survey

BALL STATE UNIVERSITY
EDUCATION REDEFINED®

Thank you for participating in this important survey we are conducting with residents of Muncie, Indiana. Ball State University graduate student, Andrew Imboden, has designed this survey to collect information regarding the consumer food environment across many USDA designated food desert areas in our city. Questions will investigate the timing and frequency of grocery shopping and considerations that influence when, where, and what groceries you buy. Your participation will require approximately 10 minutes, and your data will help determine strategies to increase access to fresh, local, and affordable grocery items in Muncie communities.

There are no known risks or discomforts associated with this survey and your participation is completely voluntary. This survey is confidential; your individual answers will not be linked with your name or other identifying material in any reports of the data. If you feel you have been treated in an illegal or unethical way, please contact the Ball State University Institutional Research Board Associate Director, John Mulcahy at (765)285-5070.

We very much appreciate your help with this study. Should you have any questions or comments, please contact me (amimboden@bsu.edu) or Joshua Gruver, graduate research advisor (765)285-5780 or jbgruver@bsu.edu.

Thank you,

Andrew M. Imboden
Natural Resources and Environmental Management
Ball State University

Instructions

- Read each question carefully as there are a mix of single answer, multiple answer, and fill in the blank.
- If you are unclear on what the question is asking, or are uncomfortable answering a particlar question, you may skip it and move on to the next.

Questions About When You Shop

1 **On which day do you prefer to shop for groceries?** *Select all that apply*

- □ Monday
- □ Tuesday
- □ Wednesday
- □ Thursday
- □ Friday
- □ Saturday
- □ Sunday
- □ No preference

2 **During what times are you most likely to shop for groceries?** *Please select your two most preferred responses.*

- □ Before 8am
- □ 8am—10am
- □ 10am—12noon
- □ 12noon—2pm
- □ 2pm—4pm
- □ 4pm—6pm
- □ After 6pm

3 **In the box below, please briefly explain what most often determines what day and time you shop for groceries.** *Ex: work schedule, vehicle availability, bus schedule, etc.*

Survey continued on next page

Questions About Your Transportation

4 **During a normal week, approximately how many times do you travel outside of your neighborhood for any reason?**

- □ Daily
- □ 5-6 times
- □ 3-4 times
- □ 1-2 times
- □ less than 1 time per week

5 **For each method of transportation, please indicate how frequently you use it to shop for groceries.** *Select only one option for each method by marking in the corresponding box.*

Method	Almost Always	Frequently	Sometimes	Rarely	Never
Walk	□	□	□	□	□
Bicycle	□	□	□	□	□
Bus/MITS	□	□	□	□	□
Personal Vehicle	□	□	□	□	□
Carpool	□	□	□	□	□
Other:_____	□	□	□	□	□

□ I do not shop

Purchasing Considerations

6 **Please indicate whether you would purchase each type of grocery item from a mobile grocery store.** *Select only one option for each food type.*

	Yes	No	I don't know
Fruits	□	□	□
Vegetables	□	□	□
Meat	□	□	□
Dairy	□	□	□

Survey continued on next page

Purchasing Considerations, continued

7 **If the price for local foods was comparable to your typical grocery store, would you prioritize purchasing *local* foods if they were available in or where you currently shop for groceries?**

- ☐ Yes
- ☐ No
- ☐ I don't know

8 **In your opinion, how important or unimportant is purchasing locally grown food?**

Very Important	Somewhat Important	Neutral	Somewhat Unimportant	Very Unimportant	No Opinion
☐	☐	☐	☐	☐	☐

9 **On a scale from 1 to 5, please rank the following considerations in order of importance when deciding <u>where</u> to shop for groceries.** *1 being most important, 5 being least important. You may write the numbers in the spaces provided.*

_____Price

_____Hours of Operation

_____Staff friendliness and product availability

_____Ease of accessibility (traffic, public transportation)

_____Distance from home

General Questions About You

10 **In what year were you born?**

YYYY

Survey continued on next page

General Questions About You, continued

11 **In what neighborhood do you live?**

□Blaine/Southeast
□Old West End
□Southside
□Whitely
□I don't know

□Other:_____

Neighborhood & Community Mapping

The following pages contain maps that display portions of Muncie, Indiana. Please use these maps to make the requested notations as it relates to your personal experience.

Focusing on the area around your home:

1. Mark an ✕ on the location you consider the center of your neighborhood.

2. Draw a line following the roads indicating your most frequently traveled routes. *(This could be on your routes to work or class, taking children to school, running errands, for recreation, etc.)*

3. Circle the roads that have the most **foot** traffic.

4. Draw a box around the roads that have the most **car** traffic.

5. Draw a triangle (▲) on areas of town that you consider unsafe and like to avoid. *(You may mark as few or as many locations as you would like)*

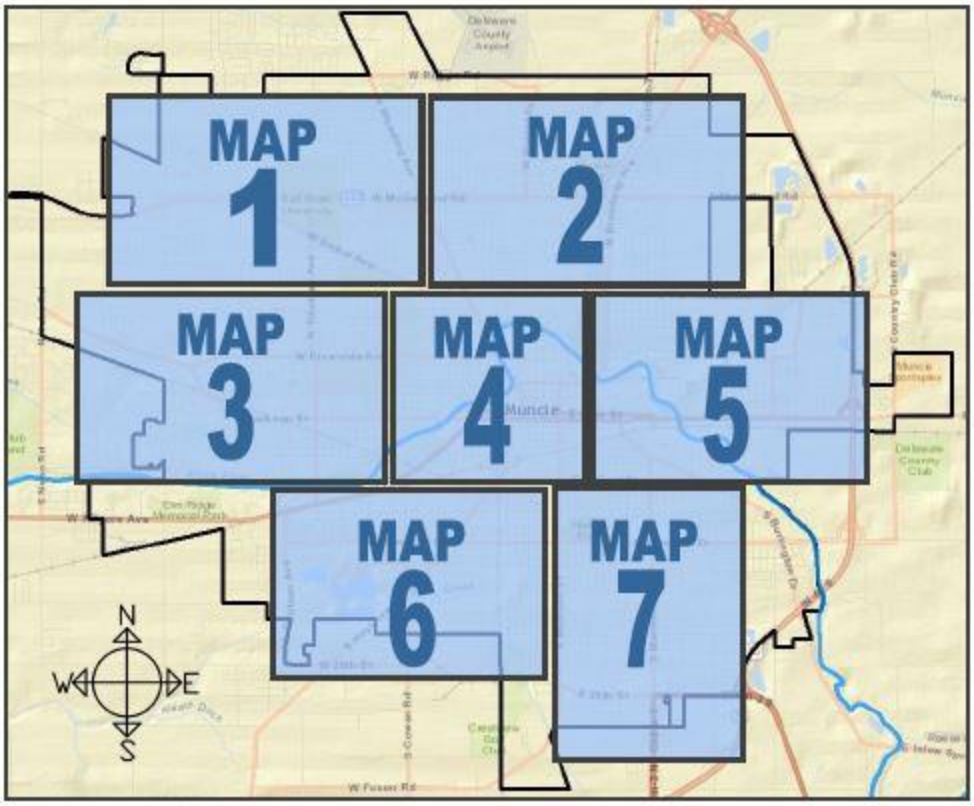
6. Draw a star (★) on the location where you would like a mobile market grocery stop to be available for you. *(You may mark as few or as many locations as you would like)*

Survey continued on next page

Neighborhood & Community Mapping

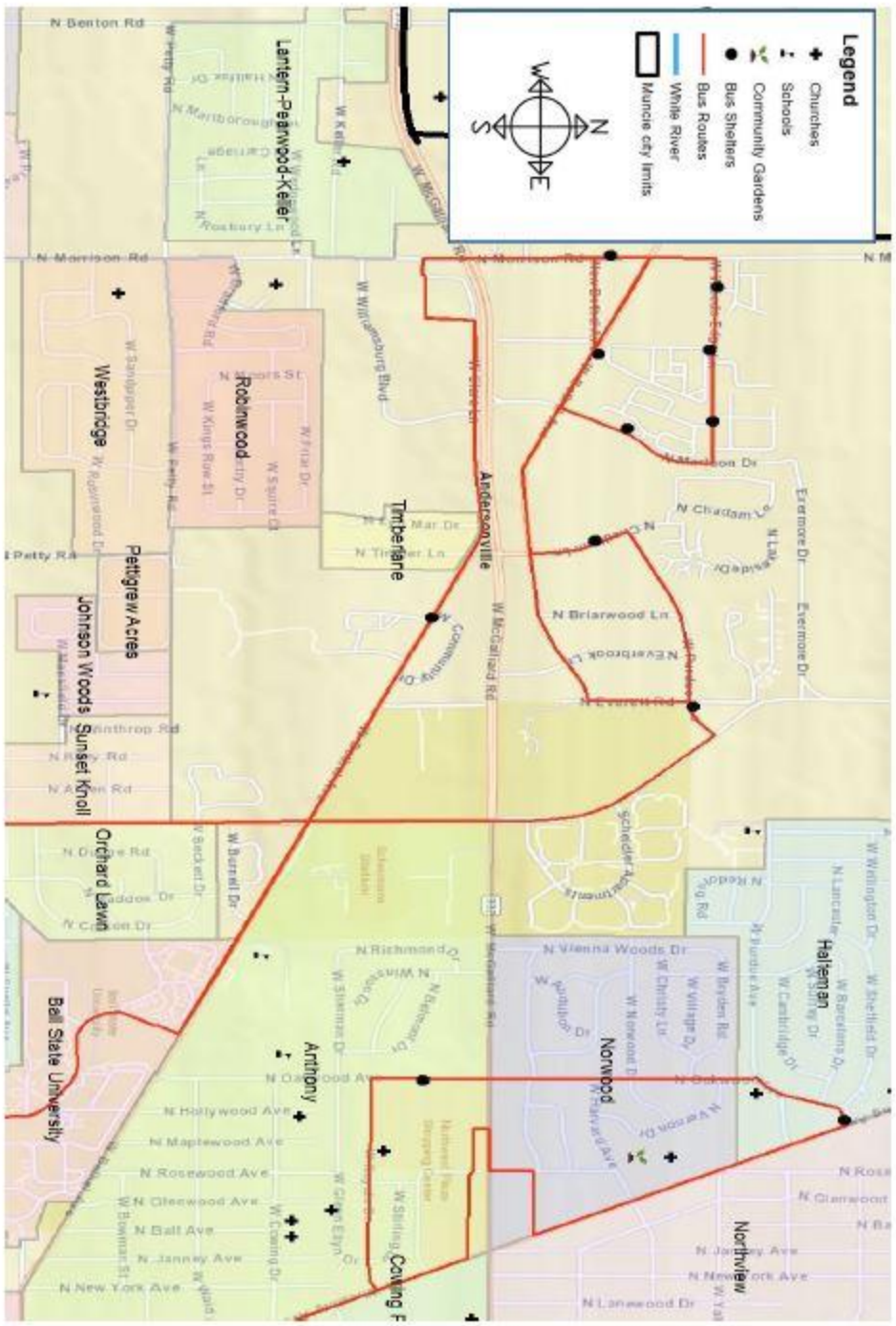
Please use the image below as a reference to more easily find the areas of town with which you are most familiar and visit most often. The numbers in the blue boxes below correspond with the title of the map on the following pages.

You are not required to make notes on every page, only the ones you are most familiar with *(i.e. where you live, work, shop, etc.)*.

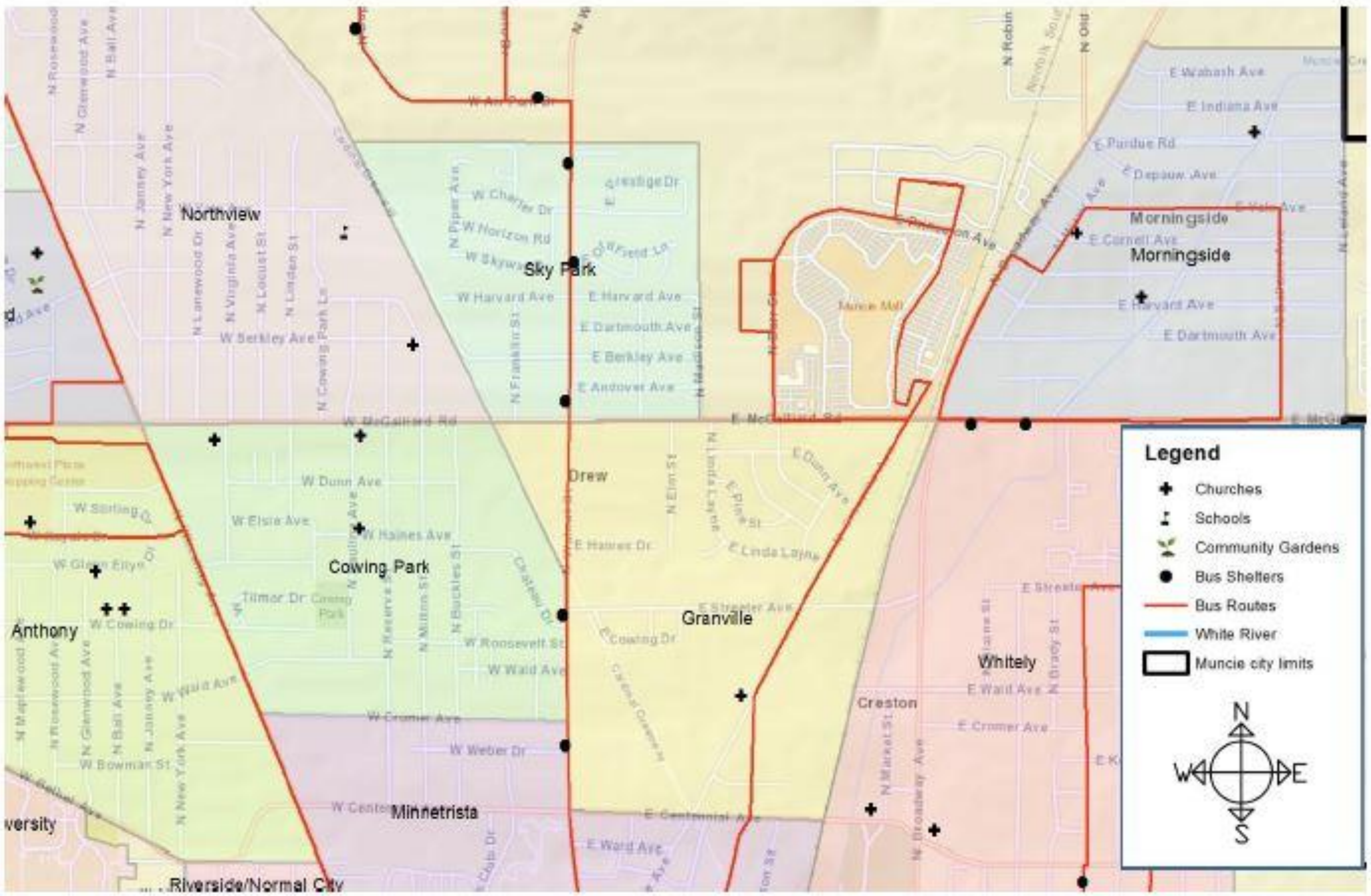


Survey continued on next page

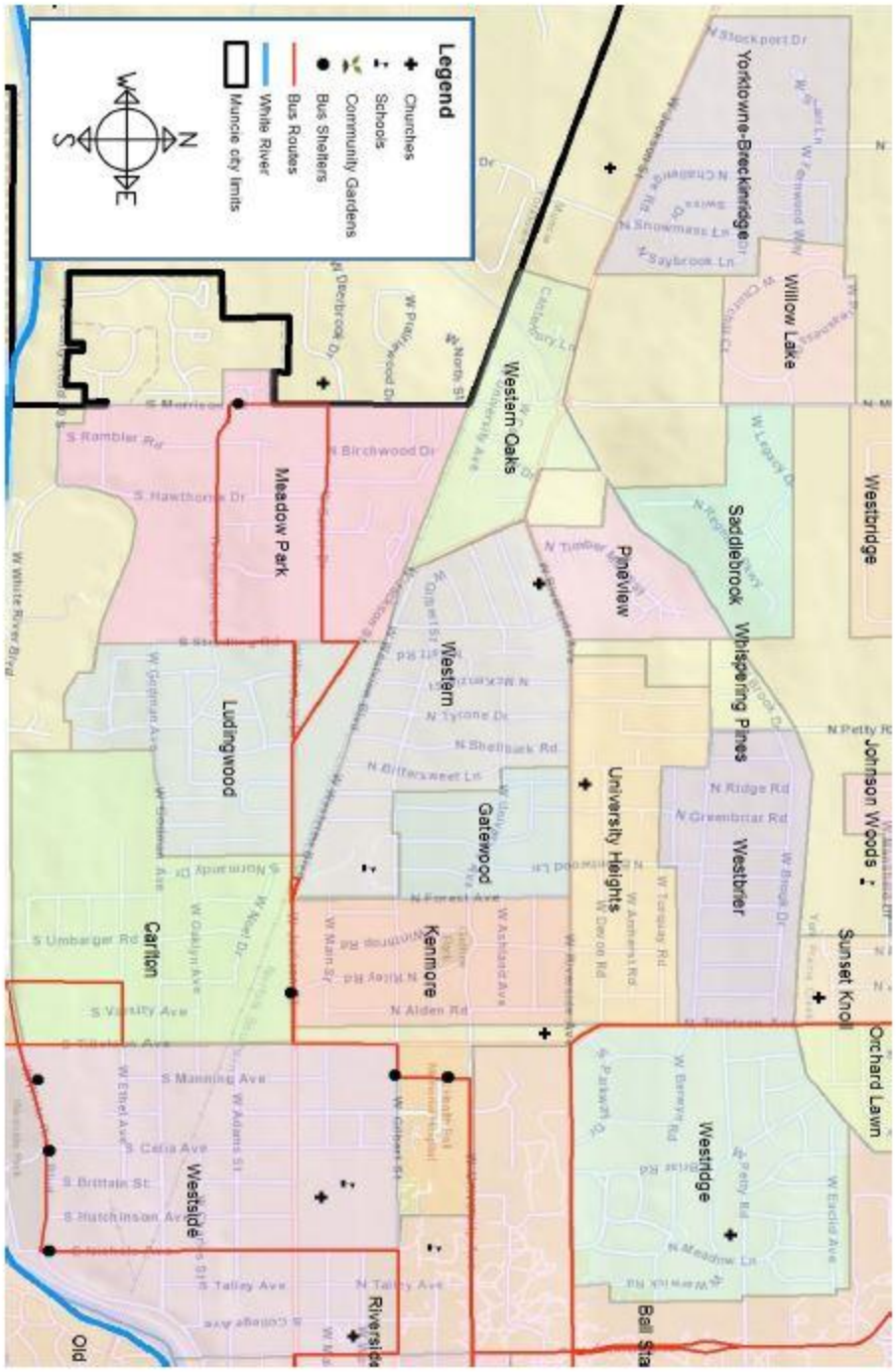
Map 1: Northwest



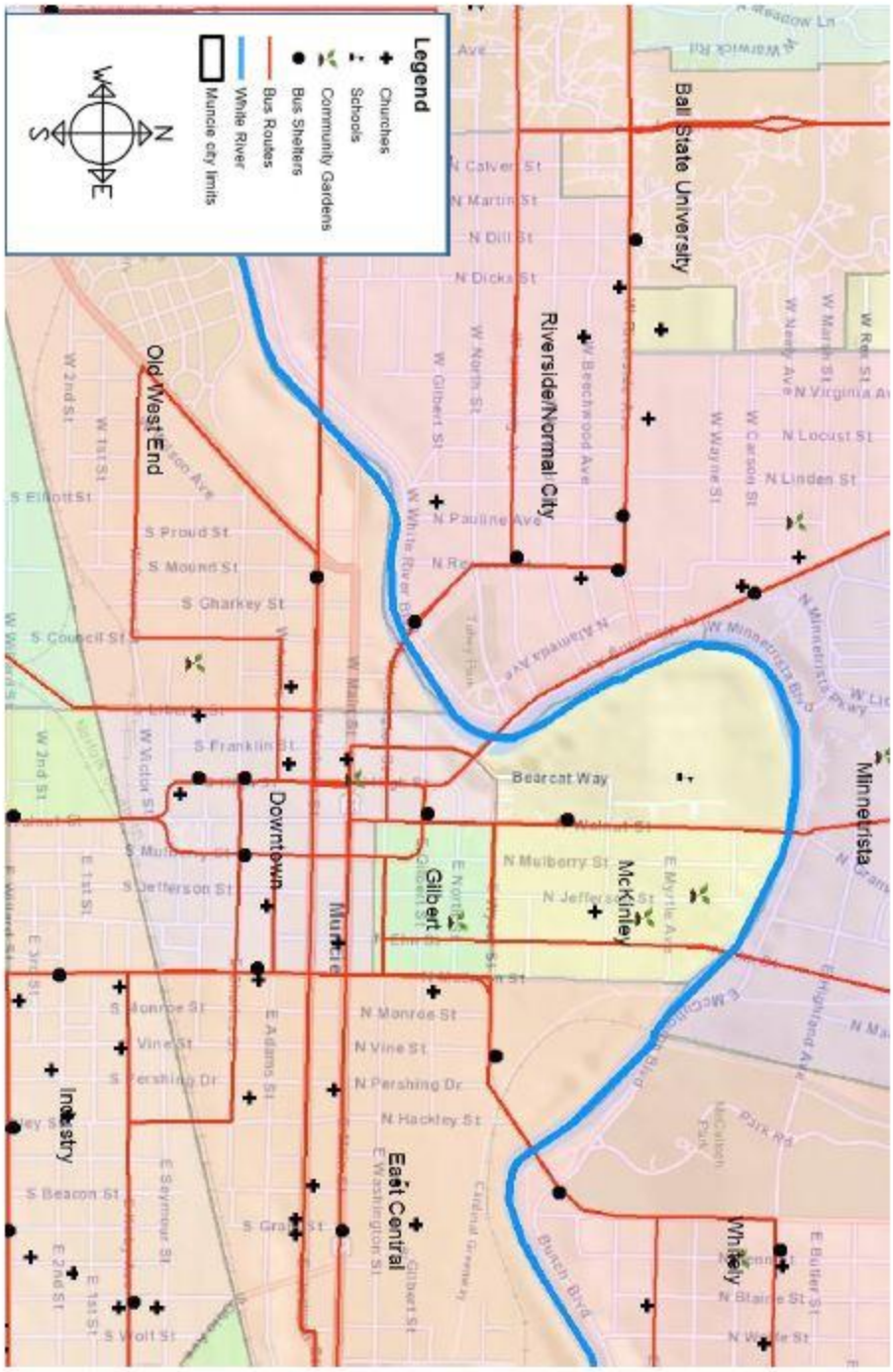
Map 2: Northeast



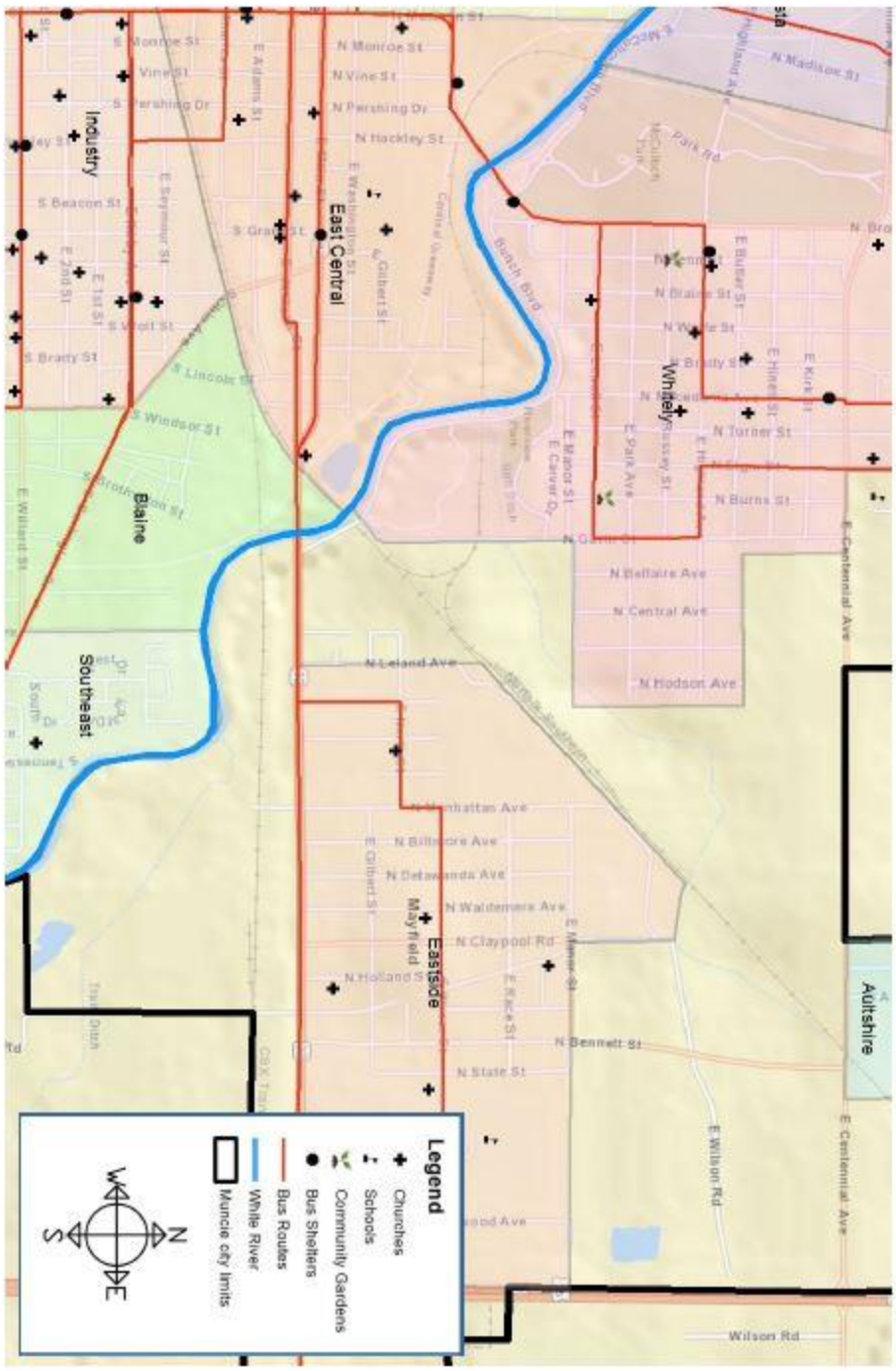
Map 1: West Central



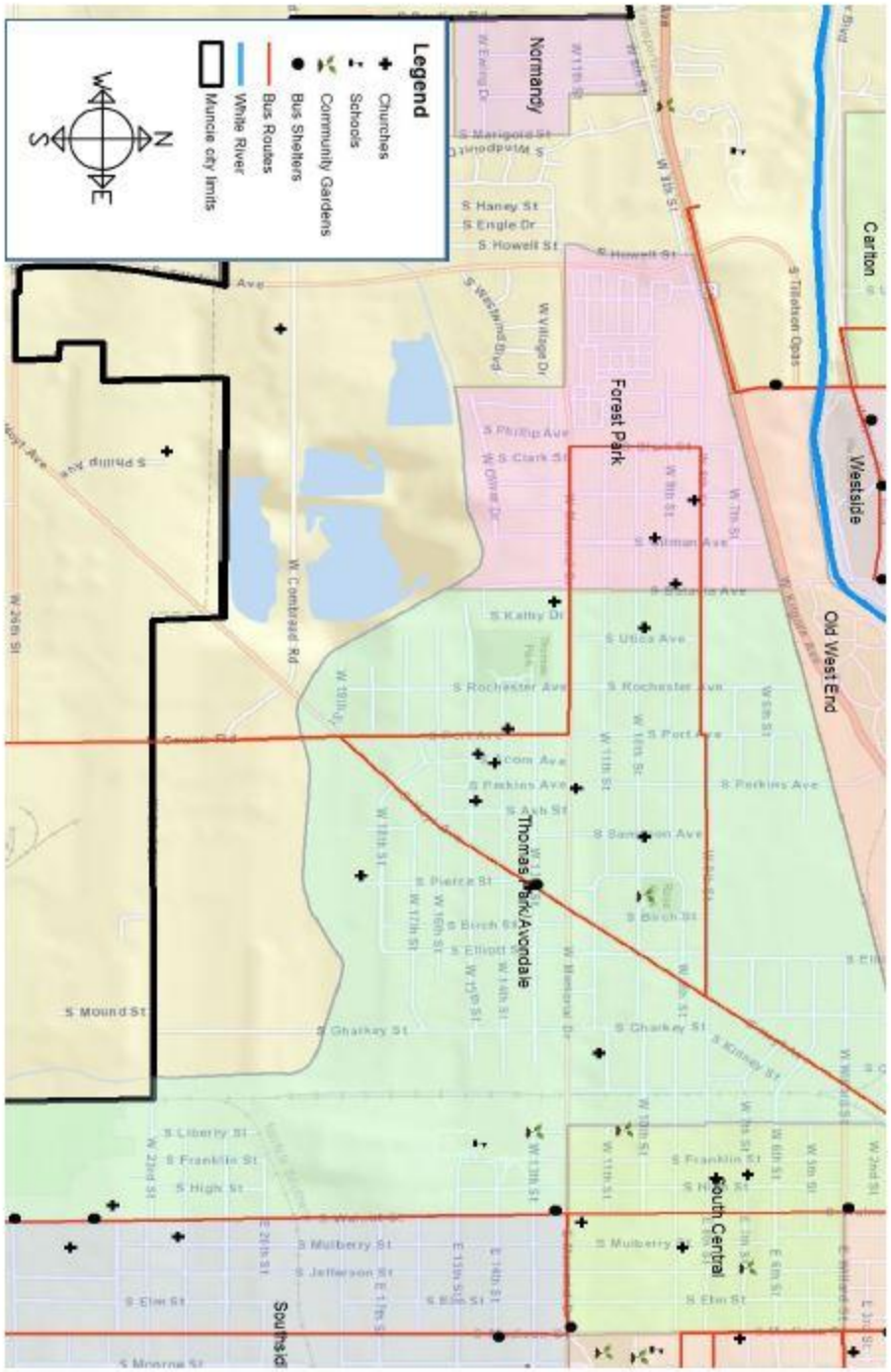
Map 1: Central & Downtown



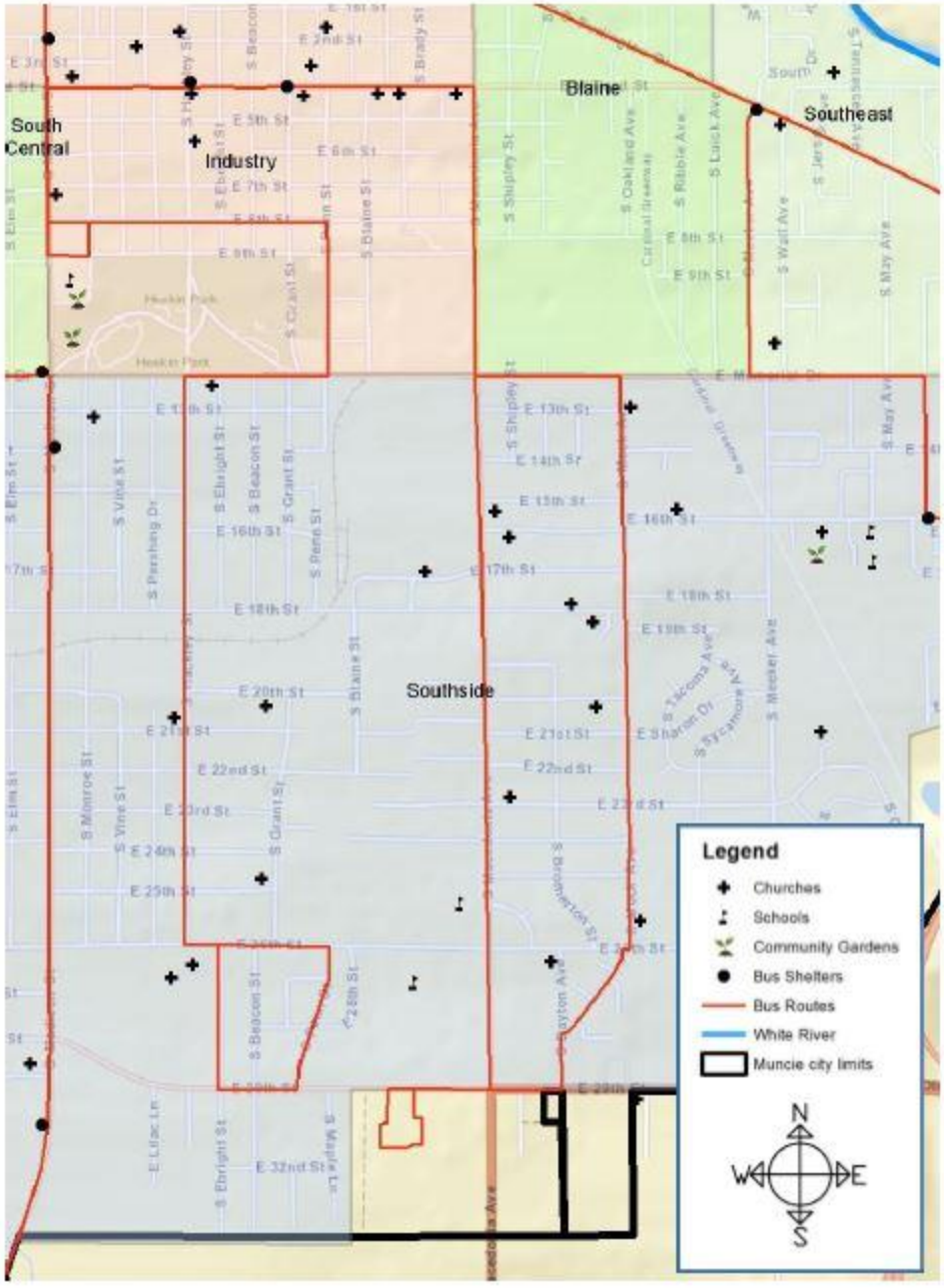
Map 1: East Central



Map 6: Southwest



Map 1: Southeast



You have completed this survey!

Thank you for your time. To submit your survey:

- Please check to make sure you have answered each question to the best of your ability.
- Place your completed survey into the pre-addressed packet provided and return it to a mailbox.

APPENDIX II

Grocery Journal

Store name & location:

_____

Date:___/___/___ ___ Time:_____am / pm

How did you get there? :

_____

What did you buy? :

_____

_____

_____

_____

_____

_____

_____

_____

_____

How much did you spend? : $____._____

Did you go shopping with anyone you know? □ Yes □ No

If yes, how many and how did you know them? :

_____